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Exemplar Candidate Work

COMPUTER SCIENCE

H446
For first teaching in 2015

H446/02 Summer 2019 series

Version 1

Contents

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Introduction

These exemplar answers have been chosen from the summer 2019 examination series.

OCR is open to a wide variety of approaches and all answers are considered on their merits. These exemplars, therefore, should not be seen as the only way to answer questions but they do illustrate how the mark scheme has been applied.

Please always refer to the specification https://www.ocr.org.uk/Images/170844-specification-accredited-a-level-gce-computer-science-h446.pdf for full details of the assessment for this qualification. These exemplar answers should also be read in conjunction with the sample assessment materials and the June 2019 Examiners' report or Report to Centres available from Interchange https://interchange.ocr.org.uk

The question paper, mark scheme and any resource booklet(s) will be available on the OCR website from summer 2020. Until then, they are available on OCR Interchange (school exams officers will have a login for this and are able to set up teachers with specific logins – see the following link for further information https://www.ocr.org.uk/administration/support-and-tools/interchange/ managing-user-accounts/).

It is important to note that approaches to question setting and marking will remain consistent. At the same time OCR reviews all its qualifications annually and may make small adjustments to improve the performance of its assessments. We will let you know of any substantive changes.

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Question 1 (a)

Exemplar 1 2 marks

1 The temperatures of an ocean are input into a computer system. They are recorded, and will be accessed, in the order in which they arrive. The data for one week is shown:

5, 5.5, 5, 6, 7, 6.5, 6

(a) The data is to be stored in a data structure. The programmer stores the data in a queue.

Explain why a queue is used instead of a stack.

A queue is first in - first out, but a stack is last in - first out. In order to retrieve the data in the correct order, i.e. Monday to Friday, not the reverse, data that went in first needs to be retrieved first, so a queue is used. A stack would return data in a week backwards. [2]

Examiner commentary

This question was firstly testing candidate's knowledge of the two data structures - queue and stack. Ideally, candidates would have stated that a queue is a first-in-first-out data structure and/or a stack is a last-in-first-out data structure. Markers would have accepted the standard abbreviations FIFO and LIFO.

The second mark was for applying this knowledge to the question in context and recognising the reasons that the queue was the most appropriate.

This candidate clearly states first-in-first-out and then gains the second mark for stating that data that is inserted first needs to be retrieved first.

Exemplar 2 1 mark

Explain why a queue is used instead of a stack.

because they ~~[illegible]~~ items can be removed in the same order they were added, ~~[illegible]~~ accessed in the same order they arrive. A stacks items are removed in backwards order. [2]

Examiner commentary

This candidate shows the rationale for choosing a queue but misses the mark for not having the knowledge of the key term first-in-first-out.

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Question 1 (b) (i)

Exemplar 1 1 mark

(b) The data is processed. After processing, the value for the first day is stored as 0. The value for each following day is stored as an increase, or decrease, from the first day.

For example: if the first day was 7, the second was 6 and the third was 9, after processing it would be stored as 0, –1, 2.

(i) The queue uses `dequeue()` to return the first element of the queue.

`dequeue()` is a function.

Explain why `dequeue()` is a function, not a procedure.

It returns a value, the first element of the queue, and functions are subroutines with a return statement, procedures don't return anything. [1]

Examiner commentary

This is a straightforward question. Candidates needed to state that functions return a value and/or that procedures do not. Note that answers such as "outputs" a value would not have been accepted as an output could be to screen.

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Question 1 (b) (ii)

Exemplar 1 3 marks

(ii) Complete the algorithm to process the data in the queue and store the results in an array called processedData.

```
processedData[0] = 0
firstDay = dequeue()
for count = 1 to 6
    processedData[count] = dequeue() - firstDay
next count
```

[3]

Examiner commentary

Candidates needed to get the correct answer only to get the marks in this question. Some candidates went wrong by failing to give the identifier in the correct case for example dequeue () instead of dequeue() or including a space between first and Day so that the answer read first Day instead of firstDay. These answers would not have been allowed as they would cause a syntax error while coding.

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Question 1 (b) (iii)

Exemplar 1

5 marks

(iii) The contents of `processedData` are shown.

0	0.5	0	1	2	1.5	1

The data needs to be sorted into ascending order.

Explain how a bubble sort algorithm sorts data. Use the current contents of `processedData` in your explanation.

bubble sort sorts data by pairing two numbers, comparing them and switching if not in order. For example 0 and 0.5 are compared, but not swapped as they are in ascending order, then 0.5 and 0 are paired and 0 is ~~moved~~ swapped with 0.5 as it is smaller. It then compares 0.5 and 1, no change, then 1 and 2, no change then 2 and 1.5 ~~which~~ this swaps, then 1 and 2 and it is swapped giving ~~0,0.5,1,1.5,2~~ 0, 0, 0.5, 1, 1.5, 1, 2 ~~this leaves~~ It then repeats this procedure until [5] it can go through every pair in the array with no swaps.

next round ~~swaps~~ 2 1.5 and 1 on the right would swap. putting it in order.

~~It should not~~

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Examiner commentary

This bubble sort question produced answers in a range of responses and markers were instructed to look for the underlying processes to find marks whether it be in text format or diagrammatic. This candidate has answered in prose and all five of the mark scheme points can be found.

Exemplar 2

5 marks

Explain how a bubble sort algorithm sorts data. Use the current contents of `processedData` in your explanation.

0, 0.5, 0, 1, 2, 1.5, 1

A bubble sort works by going through the array and comparing pairs the moving 1 to the right and comparing at each time it runs through is a pass.

pass 1 0, 0.5 0 < 0.5 so no change

0.5, 0 0.5 > 0 so moves to right

0.5, 1 0.5 < 1 no change

1, 2 1 < 2 no change

2, 1.5 2 > 1.5 switch

2, 1 2 > 1 switch [5]

0, 0, 0.5, 1, 1.5, 1, 2

Pass 2 0, 0, 0.5, 1, 1, 1.5, 2

Only switch was 1.5 > 1 so swap

Pass 3 0, 0, 0.5, 1, 1, 1.5, 2 no changes

So finished.

Examiner commentary

This candidate used a mixture of prose and diagram, again equally acceptable. The most common place for candidates to drop marks was forgetting to discuss the algorithm repeating and stating under what circumstances the algorithm would finish.

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Question 1 (b) (iv)

Exemplar 1

6 marks

(iv) A bubble sort has the following complexities:

Best time	O(n)
Average and worst time	$O(n^2)$
Worst space	O(1)

Describe what each of these complexities mean.

Best time O(n)

In the best case scenario for sorting, list already sorted, the time taken will scale linearly (n) with the size of the list as it increases. Doubling the number of items will double the best case time.

Average and worst time $O(n^2)$

If For the average used worst case, list in backwards order, the time take will scale quadratically (n^2) with the size of the list as it increases. Doubling the number of items will quadruple the average and worst case times.

Worst Space O(1)

Space complexity refers to how memory use scales with size. O(1) means the space used is constant as the list is sorted in place, data not stored anywhere else, and the space allocated to variables & the stack won't change as number of items change.

number

[6]

Examiner commentary

Marks were given for correctly naming the time/space complexity and for describing it. This candidate gains 3 marks for stating linear, quadratic and constant and a further 3 marks for the correct explanations. Relatively few candidates received full marks on this question.

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Exemplar 2

4 marks

Best time O(n)

This is linear time which means that the ~~s~~ time complexity of the data is directly ~~per~~ ~~proportionate~~ proportional to the size of the data set.

Average and worst time $O(n^2)$

This is the exponential times which means that the time complexity of the data is directly proportional to the square of the size of the data set.

Worst Space O(1)

This is constant time when the time complexity of the data executes the program at the same time no matter the size of the data set.

[6]

Examiner commentary

This candidate's answer exhibits some of the common misconceptions. They lose a mark for stating the middle complexity is exponential rather than quadratic and they lose a mark on the final complexity for failing to realise they should be commenting on space complexity rather than time.

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Question 2 (a) (i)

Exemplar 1 1 mark

2 A program needs to store the names of plants that are in a garden, so they can be easily found and accessed in alphabetical order.

The data is stored in a tree structure. Part of the tree is shown.

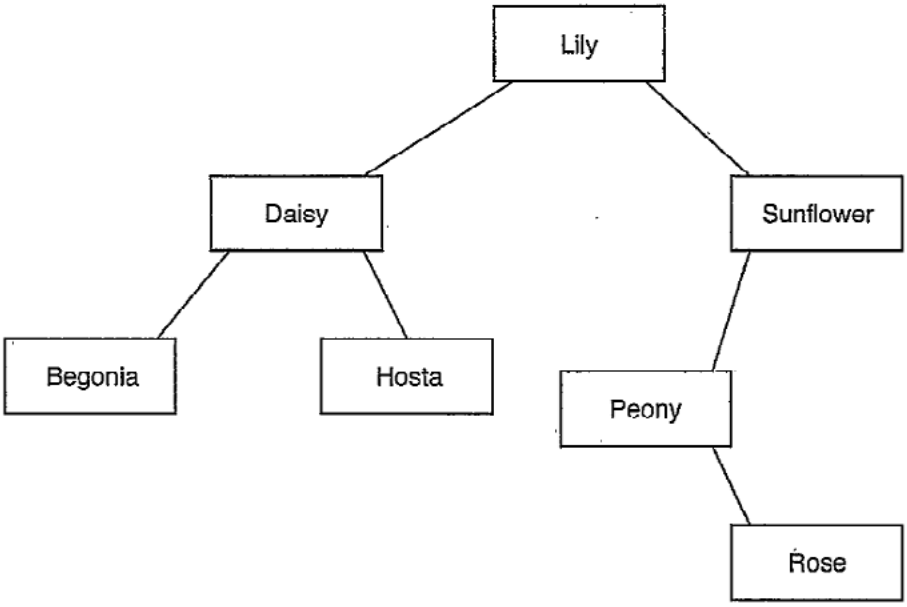

Fig. 2.1

(a) (i) State the type of tree shown in Fig. 2.1.

Binary tree ..... [1]

Examiner commentary

This question was correct answer only. Binary tree and binary search tree were the two acceptable response. Note that "binary" on its own would have been marked too vague and any abbreviation such as "BST" would also have not received the mark.

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Question 2 (a) (ii)

Exemplar 1 3 marks

(ii) Show the output of a breadth-first traversal of the tree shown in Fig. 2.1.

Lily, Daisy, Snapdragon, Begonia, Hosta, Peony, Rose

[3]

Examiner commentary

A correct answer only question – candidates needed to state the output in exactly this order to get 3 marks. Most candidates were able to do this but a few accidentally gave the order for a depth first traversal instead.

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Question 2 (a) (iii)

Exemplar 1 — 1 mark

(iii) Explain how backtracking is used in a depth-first (post-order) traversal. Use the tree in Fig. 2.1 in your explanation.

In depth-first traversal, you always visit the left most sub node of the parent node. ~~So, for the example, Lily to~~ Daisy. For post order, you want to be able to reach the right most point of the node. This means for the first item we can visit is Begonia. From here we follow along the paths of the tree until we reach Daisy. We can not get to the right side of this item for post order traversal, so we go back to Begonia to find another path. This is an example of backtracking, using trial and error to find a solution and going back to your last successful step if you have failed. Failed at Daisy, so went back to Begonia, went different path, found Hosta. [4]

Examiner commentary

This question received a wide range of answers with many candidates struggling to conceptualise what was required. This answer gives a vague description of a depth first traversal and the context of backtracking but fails to apply it to the context given so only one mark given.

Exemplar 2 — 4 marks

(iii) Explain how backtracking is used in a depth-first (post-order) traversal. Use the tree in Fig. 2.1 in your explanation.

In post-order traversal once you branch to Begonia there are no more child nodes to traverse to. Therefore, you have to backtrack to its parent, Daisy, and then branch right to Hosta. After this you must again backtrack to Daisy to continue traversing the tree.

[4]

Examiner commentary

This answer was given full marks as the context was used throughout the explanation.

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Question 2 (b) (i)

Exemplar 1 2 marks

(b) The elements in the tree in Fig. 2.1 are read into a linked list producing an alphabetised list.

(i) Complete the following table to show the linked list for the data.

Data item	Data	NextPointer
0	Begonia	1
1	Daisy	2
2	Hosta	3
3	Lily	4
4	Peony	5
5	Rose	6
6	Sunflower	null

[2]

Examiner commentary

Correct answer only for this question. Note that any widely used character for null would have been accepted such as -1 or Ø. A simple zero (0) would not have been accepted.

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Question 2 (b) (ii)

Exemplar 1

3 marks

(ii) A new plant, Lavender, needs adding to the linked list. The linked list needs to retain its alphabetical order.

Complete the table to show the linked list after Lavender is added.

Data item	Data	NextPointer
0	Begonia	1
1	Daisy	2
2	Hosta	7
3	Lily	4
4	Peony	5
5	Rose	6
6	Sunflower	null
7	Lavender	3

[3]

Examiner commentary

Correct answer only. Again, a wide range of symbols for null would be accepted but zero would not be.

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Question 2 (b) (iii)

Exemplar 1 4 marks

(iii) Hosta needs removing from the linked list.

Explain how a data item is removed from a linked list. Use the removal of Hosta in your answer.

To remove ~~too~~ Hosta a data item the pointer of the item before Hosta it in the list, in this case Daisy is before Hosta, will have ~~the~~ to be changed to the value of the pointer of the item to be removed. So in this case Daisy's pointer, 2, will be changed to Hosta's, becoming ~~seven~~ 7. This will have removed Hosta as Daisy now points to Lavender, missing out Hosta.

[4]

Examiner commentary

This question receives 4 marks as the candidate has discussed the pointers to be changed and the values they change from/to. Other good answers discussed the need to iterate through the linked list in the beginning to find the item to remove.

Exemplar 2 0 marks

A linked list is a dynamic data structure. ~~that is used to store data items~~ The data item is removed by using the function 'remove which means that the data item in that position is null. Once the data item is removed, the ~~list becomes~~ position becomes free. This means that the last data item in the list will have the pointer pointing to the next position ~~that is free~~ that has nothing. This means that position is next free for a new item to be added. While it remains free, the ~~data item~~ other data items will skip the free position. [4]

Examiner commentary

This answer is an attempt at a vague description of a linked list. The candidate has not used the removal of Hosta in their answer (i.e. no context) and many of the statements made are incomplete or incorrect.

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Question 2 (b) (iv)

Exemplar 1 5 marks

(iv). The linked list is stored as a 2D array with the identifier `plantList`. The index of the first element of the linked list is stored in the identifier `firstElement`.

All contents of the linked list need to be output in alphabetical order.

Write an algorithm to follow the pointers to output the contents of the linked list in alphabetical order.

Add comments to explain your code.

```
//output linked list (assuming alphabetical order) alphabetically
//start at first element
int currentElement = firstElement
// print each item's Data, until the next pointer is -1
do
    Print(plantList[currentElement].Data)
    currentElement = plantList[currentElement].NextPointer
While (currentElement ≠ -1)

//-1 means the end has been reached
```

[5]

Examiner commentary

Full marks for this answer. The algorithm clearly starts at the first element, there are clear comments, the data is outputted and the algorithm follows the pointers. The candidate has used a do-while loop which is fine.

Exemplar 2 1 mark

```
//stores list of items as a string.   rawplants = str(plantlist[firstElement])
                                      n = len(plantlist) //gets number of items
                                      for(i = 1 until i > n, i++) //goes through table
                                                                  from i=1 till i=n
                                      plant = str(plantlist[i]) //turns item of list to string
                                      plants = plants + ", " + plant //adds item in list
                                                                     to plants string
                                      print(plants) //prints list of plants as a string
```

Examiner commentary

This candidate's answer highlights a common misconception. The candidate has attempted to iterate through the linked list using a standard for loop which isn't possible due to the nature of the pointers. This answer just gets the 1 mark for adding comments.

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Question 3 (a) (i)

Exemplar 1 1 mark

3 A recursive function, GCD, is given in pseudocode.

```
function GCD(num1, num2)
        if num2 == 0 then
                return num1
        else
                return GCD(num2, num1 MOD num2)
        endif
endfunction
```

(a) The function uses branching.

(i) Identify the type of branching statement used in the function.

IF statement ..... [1]

Examiner commentary

Correct answer only.

Exemplar 2 0 marks

(i) Identify the type of branching statement used in the function.

return GCD (num 2, num 1 MOD num 2) ..... [1]

Examiner commentary

Many candidates over thought this question. This candidate has incorrectly confused branching with recursion. Other candidates stated "branch if zero" as answer as they had confused the concepts with the Little Man Computer and assembly.

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Question 3 (a) (ii)

Exemplar 1 2 marks

(ii) Explain the difference between branching and iteration.

Iteration is when one section of code is repeated ~~with~~ while a condition is true, branching is when the program flow jumps to another point depending on if a condition is true or not.

..... [2]

Examiner commentary

The two marks for this question were given for firstly describing iteration as a process that repeats a section of code and secondly describing that branching will choose to run a section of code depending on a condition.

Exemplar 2 0 marks

(ii) Explain the difference between branching and iteration.

Iteration is utilized to execute a number of loops in a program that is running. Branching is utilized to give the execute the address given without any condition of the return ~~value~~ value.

..... [2]

Examiner commentary

This candidate correctly identifies that iteration involves loops but it is a general, vague answer not specific enough to be given marks at this level. They then give a wholly incorrect definition of branching, perhaps mixing it up with recursion.

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Question 3 (a) (iii)

Exemplar 1 1 mark

(iii) Identify the **two** parameters in the function.

1 num1

2 num2

[1]

Examiner commentary

Most candidates correctly identified the two parameters as shown.

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Question 3 (a) (iv)

Exemplar 1 2 marks

(iv) State whether the parameters should be passed by value, or by reference. Justify your answer.

They should be passed by value otherwise they would be changed anywhere in the code, so all calls of the recursive function would have the same value, breaking the recursive aspect as all variables would have separate values. [2]

Examiner commentary

This candidate gets both the marks. Firstly, for correctly identifying that the parameters should be passed by value and then for stating the reason.

Exemplar 2 1 mark

(iv) State whether the parameters should be passed by value, or by reference. Justify your answer.

The parameters should be passed by values as the program is going to execute two numbers from the subroutine. Using reference ~~does not~~ is not suitable with what the program wants to return. [2]

Examiner commentary

Many candidates struggled to give an adequate reason why the parameters should be passed by value. This candidate gets the first mark for stating by value but then provides a vague answer not worthy of credit.

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Question 3 (a) (v)

Exemplar 1 2 marks

(v) Describe the arithmetic operation of MOD. Use an example in your answer.

MOD finds the remainder when the value before it is divided by the value after it.

e.g. 22 MOD 5 = 2

because 22 ÷ 5 = 4 remainder 2 [2]

Examiner commentary

One mark given here for stating mod gives the remainder of a division and one mark for a correct example.

Exemplar 2 0 marks

(v) Describe the arithmetic operation of MOD. Use an example in your answer.

MOD checks how many time a number goes into another number. If you divide one number by another MOD will just give the integer not the rest without the fraction part.

e.g 12 MOD 5 = 2 but 12 ÷ 5 = 2.4

[2]

Examiner commentary

This candidate has mixed up a mod operation with a div (integer division) and so receives no marks.

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Question 3 (b)

Exemplar 1 0 marks

(b) Trace the recursive function when it is called by the statement `GCD(250, 20)`. Give the final value returned.

num1	num2	mod
250	20	
20	1	1
1	0	0

Final return value: 1

[3]

Examiner commentary

There were lots of formats for the answers to this question – all of which were allowed. This candidate, however, has been unable to trace the function correctly and so receives no marks.

Exemplar 2 3 marks

(b) Trace the recursive function when it is called by the statement `GCD(250, 20)`. Give the final value returned. num 1 num 2

1) 250, 20

2) 20, 10

3) 10, 0

4) 10, 0 returns num 1, 10.

On the 3rd recursion of the function, a value of 10 is returned.

Final return value: 10

[3]

Examiner commentary

This is an alternative format for the answer. This candidate successfully traces the function and receives all 3 marks.

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Question 3 (c) (i)

Exemplar 1 2 marks

(c) The function has been rewritten using iteration instead of recursion.

(i) State **one** benefit and **one** drawback of using iteration instead of recursion.

Benefit Uses less memory as there aren't many calls of the function at once, so less chance of a stack overflow.

Drawback Can be more difficult to code as some problems are naturally recursive.

[2]

Examiner commentary

These two responses are virtually textbook quality and straight from the mark scheme so two marks given.

Exemplar 2 0 marks

(i) State **one** benefit and **one** drawback of using iteration instead of recursion.

Will keep looking until condition is met allows for more functionality

Benefit Last line of return straight away even if condition not met, doesn't wait for condition to be met.

Drawback Can be ~~less efficient~~ more difficult to code, and return isn't given straight away

[2]

Examiner commentary

Many candidates gave vague answers to this question that did not show the understanding required. This candidate is an example: "more functionality" doesn't mean anything in the context and "return isn't given straight away" is not a drawback.

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Question 3 (c) (ii)

Exemplar 1

4 marks

(ii) Complete the missing statements in this iterative version of the function.

```
function newGCD(num1, num2)
  temp = 0
  while (num2 != 0)
    temp = num2
    num2 = num1 MOD num2
    num1 = temp
  endwhile
  return num1
endfunction
```

[4]

Examiner commentary

A straightforward question – correct answer only. This candidate receives all four marks although relatively few candidates were able to unpick the algorithm enough to do this.

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Question 4 (a)

Exemplar 1 2 marks

4 Mabel is a software engineer. She is writing a computer game for a client. In the game the main character has to avoid their enemies. This becomes more difficult as the levels of the game increase.

(a) Mabel uses decomposition to design the program.

Explain how decomposition can aid the design of this program.

Decomposition is breaking down a large problem into smaller ones, for example the game could be split into player movement, enemy movement and level generation. This task could then be broken down more, this makes each part simpler to design. It is easier to work on each part separately. [2]

Examiner commentary

The candidate gets the two marks here: the first one for saying the problem is broken down and the second for giving a reason why that is beneficial. Most candidates found this question to be straightforward and gained both marks.

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Question 4 (b) (i)

Exemplar 1

6 marks

(b) The computer game allows a user to select a character (e.g. name, gender). They can then choose a level for the game (easy, normal, challenging). The user controls their character by moving it left or right. The character can jump using space bar as an input. If the character touches one of the enemies then it loses a life. The character has to make it to the end of the level without losing all their lives.

The game is designed in a modular way.

(i) One sub-procedure will handle the user input.

Describe **three** other sub-procedures Mabel could create for the given game description.

1 One procedure could handle character selection, creating a character with the characteristics the user has selected.

2 One procedure could handle the movement of the enemies throughout the level. Letting them try to damage the player by moving across the screen.

3 Another could handle the player taking damage. It could check to see if the user & enemy overlap and remove 1 life if they are.

[6]

Examiner commentary

Three marks for correctly identified subroutines and three marks for expansion. This is another question that most candidates found straightforward.

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Exemplar 2

4 marks

(i) One sub-procedure will handle the user input.

Describe **three** other sub-procedures Mabel could create for the given game description.

1 when a character touches an enemy, that their lives decrease, or if their empty to restart the level.

2 the menu, where a character and difficulty is selected, to change the level, or other settings and to start.

3 an end procedure, for when the person has completed the level, if they want to continue.

[6]

Examiner commentary

This candidate has missed the marks for the second point as it is not clear what the procedure is.

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Question 4 (b) (ii)

Exemplar 1 2 marks

(ii) Describe the decision that the program will need to make within the user input sub-procedure and the result of this decision.

I first must decide whether the the character should move and what direction they should have, it will use the inputs given to decide. The result will be either the character moves left, right, jumps or does nothing. [2]

Examiner commentary

Clear identification of the decision that is made and a clear identification of the result – 2 marks.

Exemplar 2 0 marks

(ii) Describe the decision that the program will need to make within the user input sub-procedure and the result of this decision.

the difficulty in the decision it will need to make as it will result in different gameplay experience for the user for example changing challenging may cause speed of enemy movement to double [2]

Examiner commentary

Where candidates dropped marks it was often because they had missed the context of the question. This candidate has discussed changing the difficulty setting but that isn't part of the scenario given for the user input.

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Question 4 (b) (iii)

Exemplar 1 2 marks

(iii) Define pipelining and give an example of how it could be applied in the program.

Pipelining is when while one instruction is being ~~com~~ executed another is being decoded and another is fetched. In this case while a character is completing a movement up then the next input could be being read. [2]

Examiner commentary

This candidate clearly describes pipelining and can apply it to the scenario.

Exemplar 2 0 marks

(iii) Define pipelining and give an example of how it could be applied in the program.

Pipelining is having multiple operations simultaneously being completed, in this case it would involve processing ~~Handling~~ user ~~input~~ next move whilst outputting user movement on AI which is comparing Coordinates to check for collision and deduct ~~lives~~ lives. [2]

Examiner commentary

Many candidates fell into the trap of confusing pipelining with concurrency. This candidate receives no marks as the definition of pipelining is not clear.

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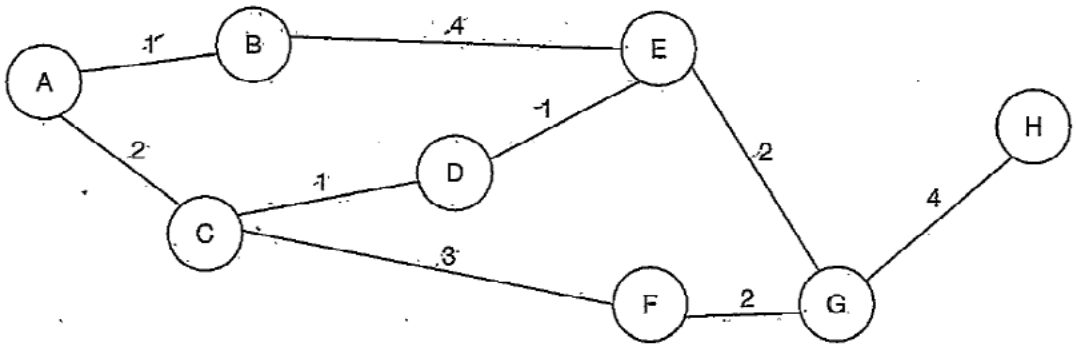
Question 4 (c)

Exemplar 1 6 marks

(c) The game's 'challenging' level has intelligent enemies that hunt down the character in an attempt to stop the user from winning. The program plans the enemies' moves in advance to identify the most efficient way to stop the user from winning the game.

The possible moves are shown in a graph. Each node represents a different state in the game. The lines represent the number of moves it will take to get to that state.



Show how Dijkstra's algorithm would find the shortest path from A to H.

Node	Visited	Cost	Prev. node
A	No Yes	0	N/A
B	No Yes	∞ 1	A
C	No Yes	∞ 2	A
D	No Yes	∞ 3	C
E	No Yes	∞ 8 4	B D
F	No Yes	∞ 5	C
G	No Yes	∞ 6	E
H	No Yes	∞ 10	G

Starting at A, all adjacent nodes from the current node are tested and a cost equal to cost of current node + edge cost, it replaces the node's cost if the new cost is less. Once this is done for all adjacent nodes, mark current node as visited. Choose node with lowest cost as new node. Repeat until all nodes visited.

AH:

ACDEGH = 10

[6]

Examiner commentary

There were many approaches attempted by candidates. This method was common and usually led to candidates scoring all the marks.

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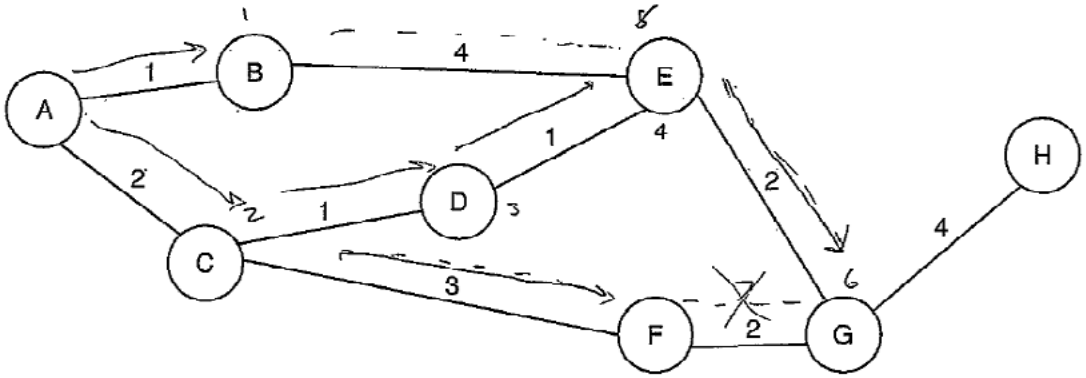
Exemplar 2

6 marks

(c) The game's 'challenging' level has intelligent enemies that hunt down the character in an attempt to stop the user from winning. The program plans the enemies' moves in advance to identify the most efficient way to stop the user from winning the game.

The possible moves are shown in a graph. Each node represents a different state in the game. The lines represent the number of moves it will take to get to that state.



Show how Dijkstra's algorithm would find the shortest path from A to H.

First, Dijkstras takes the closest node from A, to B and records the value 1, for B. From B, the cost to C is also found to be 5. The algorithm backtracks to A and traverses to C, whose lowest cost is set to 2. D is then traversed and set to a 3rd lowest cost of 3. E is then found to have a shorter path to get too and is changed from a cost of 5 to 4. E is traversed and G has a cost of 6. The algorithm then ~~backtracks to continues to~~ G backtracks to C and traverses to F, which has a cost of 5 calculated along with G as a cost of 7, although a lower cost ~~exis~~ path exists so its discarded. The algorithm then returns to G and traverses to H, which finally has a cost of 10 calculated for its shortest path, going through ~~node~~ the following nodes in this order: A, C, D, E, G and H.

[6]

Examiner commentary

This candidate also received full marks but this time submitted a prose response. Some candidates who attempted a written response found themselves confused and dropped some marks. The tabular version is preferred as the logical layout allows candidates to focus on the algorithm and save examination time.

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Question 4 (d)

Exemplar 1

5 marks

(d)* Mabel has been told that true programmers write programs in a text editor, and do not use IDEs. Mabel does not agree with this statement.

Discuss the use of an IDE in the development of this program.

An IDE is an integrated development environment which is an applic piece of software used in programming and developing a project. It contains many features to aid development, which could make it appear less pure than a text editor, but they are incredibly useful for modern development and work alongside the programmers skills. One use of an IDE is the debugger for locating and fixing bugs, it has many features such as a step command where the code can be stepped through line by line to follow the program flow. Alongside this variables are often traced to help find errors. In Mabel's program she could use this to follow player attributes if there was a bug relating to them. IDE's often gives real time syntax errors which speeds up the development Mabel won't need to compile to find each syntax error. They also provide development tools unrelated to the coding, for example version control which Mabel could use if she wanted people to test specific versions or betas of the game. Finally, since she is designing it in a modular way an IDE is useful as it can often show the program project structure and even create structure diagrams, allowing her to easily follow her design. Overall however an IDE will greatly benefit Mabel's development of the program due to the number of tools given to the developer. [9]

AO1: - Define
- Explain

AO2: IDE: + Debugger
↳ Step
↳ Variable tracing
+ Syntax checker
+ Version control → Betas
+ Program structure → Modules

Cohesion:
+ Follow design
+ player attributes

AO3: + Very useful
+ Increase productivity

Examiner commentary

This candidate can show lots of knowledge about the topic area and there is a significant amount of application to the question. The evaluation is relatively weak though merely stating that an IDE would provide some tools so this sits in the middle band.

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Exemplar 2

3 marks

(d)* Mabel has been told that true programmers write programs in a text editor, and do not use IDEs. Mabel does not agree with this statement.

Discuss the use of an IDE in the development of this program.

IDE stands for integrated development ~~pro~~ environment. This is an application of a programming language that can be utilized to write ~~coded~~ source code within a program so that it can be tested. IDE can be utilized to write code and run the code to see if its executable ~~sc~~ ~~runs the ex~~ and executes the expected output. The use of IDE in the development of this program also includes subroutines which run a specific task within the program. This helps the programmers maintain the program especially when ~~changes need to be made~~ modifications need to be made. The program also ~~provides a pop up with the errors with~~ allows the user to find out whether the programmer to identify new errors that are developed during the running of the program. This helps the programmer to modify their code quicker when they are told about the errors such as ~~syntax~~ syntax errors that are made within the program. IDE can be useful in terms of adding comments to ~~find out~~ display & how the program is run thereby making it easier for a user to understand what the program is meant to do. The use of variable names can also allow subroutines to be called and executed. [9]

Examiner commentary

Many candidates fell into the trap of producing answers like the one submitted by this candidate. The response shows excellent knowledge about the features and functions of an IDE but the candidate hasn't actually answered the question and has not made any attempt to relate the answer to the question therefore this is a Level 1 response.

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Question 5 (a)

Exemplar 1

6 marks

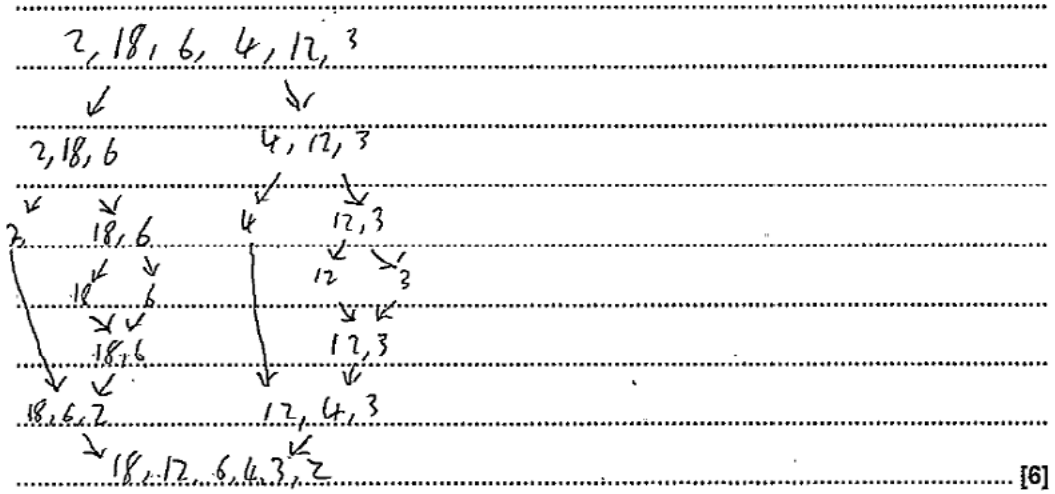
5 A 1-dimensional array stores the following data:

Index	0	1	2	3	4	5
Data	2	18	6	4	12	3

(a) The array needs sorting into descending order.

Describe how a merge sort would sort the given array into descending order.

A merge sort is completed by splitting an list in half then merge sorting each half, then combining each sorted half into 1 sorted list by looking at the first item of each list and putting the larger one into the new list until all are placed. The base case is 2 lists of length 1 which are just placed into descending order.



[6]

Examiner commentary

Many candidates submitted responses like this one with a mix of prose and a diagram. This was effective at gaining the marks and the six marks could have been gleaned from various parts of the response.

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Exemplar 2 1 mark

5 A 1-dimensional array stores the following data:

Index	0	1	2	3	4	5
Data	2	18	6	4	12	3

(a) The array needs sorting into descending order.

Describe how a merge sort would sort the given array into descending order.

The merge sort would sort the array by splitting the data into two parts where one part will show 2, 18, 6 and the other part shows 4, 12, 3. The ~~following~~ first part and the second part will be ordered ~~as~~ to its correct position. For example, the first part will be sorted into descending order by showing 18, 6, 2. The second part will be sorted to 12, 4, 3. Now that the both parts are sorted in descending order, they can be merged together to into descending order. The final output will show 18, 12, 6, 4, 3, 2. [6]

Examiner commentary

This candidate has remembered that the merge sort is a divide and conquer algorithm so gains the first mark. After that, the response breaks down and it is clear that the understanding of the algorithm isn't being shown.

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Question 5 (b)

Exemplar 1 2 marks

(b) An insertion sort can be used to sort the array instead of a merge sort.

Explain why an insertion sort might use less memory than a merge sort.

Insertion sort is completed in place, just swapping values in the original array, whereas merge sort uses another array to sort the values into. Using another array, so using an insertion sort in place won't use another array, so may use less memory. [2]

Examiner commentary

The candidate gains both marks here – firstly for stating an insertion sort happens "in place" and secondly for stating merge sort uses additional arrays.

Exemplar 2 1 mark

Explain why an insertion sort might use less memory than a merge sort.

because an insertion sort doesn't require a seperate sub selections for each number as it has two lists one for sorted and one for unsorted, using less memory.

Examiner commentary

This is a relatively vague response, but it was felt that there was enough for one mark as a benefit of the doubt as the candidate seems to show an understanding of using sub lists.

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Question 6

Exemplar 1 4 marks

6* Benedict runs a social networking website. He has been told he should use data mining to help him enhance and improve his website.

Evaluate the use of data mining to help Benedict enhance and improve his social networking website.

Data mining is utilized to look at large data sets in a certain database to look for any hidden connections or future trends. Data mining is only suitable on large data sets ~~which~~ that contain a large set of data. This is because it will be very difficult for a user to discover hidden connections or future trends with a ~~very~~ very large data set. With the use of data mining, Benedict can improve his social networking website by searching for data that ~~does not follow~~ is not appropriate on the site. For example, inappropriate pictures that are posted on the ~~new~~ social networking website can be removed instantly or in addition to ~~an~~ adding punishment to the user that ~~that~~ posted the data. This provides Benedict with better security of his ~~website~~ social network from ~~the~~ instances such as cyberbullying, inappropriate images etc.

Examiner commentary

This candidate accurately shows a wide range of knowledge about what data mining is and some of the general advantages and disadvantages. They then apply it to the question but the application is weak and only partially correct so this falls into the low end of the middle band.

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Exemplar 2

7 marks

Evaluate the use of data mining to help Benedict enhance and improve his social networking website.

Data mining would allow Benedict to target any users on his site by gathering data and ~~browse~~ browsing information for increasing the time they spend on Benedict's website. Data mining would also allow Benedict to collect data on his user's devices for his social network, allowing him to target development for certain devices (such as mobile). Data mining would also help Benedict to possibly improve his website by being able to give users suggestions and other useful features based on a user's individual data profile. However, there are downsides. Benedict would have to follow all appropriate data protection laws, such as the UK's Data Protection Act (DPA) and the EU's GDPR. Any data, under the DPA, would have to be used only for its intended purpose and be securely stored, otherwise he could face legal repercussions. Users may also prefer not to be datamined, in which case under GDPR he would have to provide an option for easily opting out of datamining for his users. Overall though, as long as Benedict stays within the law, datamining could help him enhance and improve his website. [9]

Examiner commentary

This candidate displays a wide range of knowledge, all of which is applied to the question covering a range of aspects of the context. There are some evaluative statements and it is good to see the higher order thinking required to bring in other parts of the specification (e.g. GDPR).

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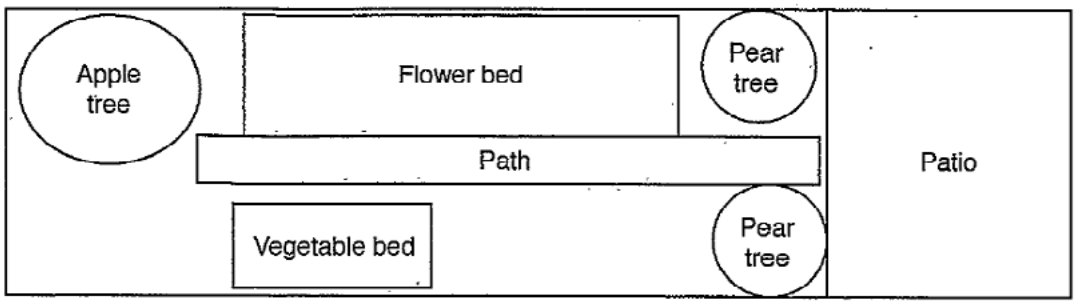
Question 7 (a) (i)

Exemplar 1 2 marks

7 A program is needed to plan the layout of a garden.

The program will allow the user to create an image of the garden, for example:



(a) The programmer will use abstraction to produce the program interface to represent the garden.

(i) Give **two** different examples of how abstraction has been used to produce the layout of the garden.

1 Trees have been reduced to just circles, individual leaves, branches or trunk are not included.

2 Path is just a rectangle, no indication of material or how it looks in real life.

[2]

Examiner commentary

There were a wide range of possible answers to this question and most candidates were able to gather two marks. This candidate has given two reasonable examples of abstraction so is given both marks.

Exemplar 2 1 mark

(i) Give **two** different examples of how abstraction has been used to produce the layout of the garden.

1 Abstraction has been used by producing the amount of space that will be taken by the each substance in the garden.

2 Abstraction has also been utilized how the shape of the substances in the garden are equivalent to.

[2]

Examiner commentary

This candidate perhaps hasn't understood the nature of the question or what is meant by abstraction. One mark can be given for the abstraction of shapes.

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Question 7 (a) (ii)

Exemplar 1 1 mark

(ii) Explain the need for abstraction in the production of this program.

It would be ~~impossible~~ very difficult to model every detail such as leaves, blades of grass or ~~flowers~~ or branches and they are not relevant in creating a plan of the garden. In order to create a simple relevant model it's be abstracted to just the essential characteristics of the garden. [3]

Examiner commentary

This response receives the mark for stating that not all the details of a real garden are necessary to the program but the candidate fails to comment on the production of the program i.e. saving memory, time, resources, money.

Exemplar 2 1 mark

(ii) Explain the need for abstraction in the production of this program.

Abstraction is needed as it simplifies the problem by removing unnecessary details that don't aid the purpose of the program. And as its purpose is to simply plan the layout it doesn't need to take into consideration the shapes or colours, just the area and location of garden. This makes it easier to develop as programmer doesn't have to develop code that doesn't serve a purpose in the ~~real~~ job of the program. Saves time and waste. [3]

Examiner commentary

Many candidates submitted answer like this – the candidate has explained what abstraction is (which wasn't required by the question) and then only vaguely applied it to the production of the program.

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Question 7 (a) (iii)

Exemplar 1 3 marks

(iii) The user needs to input data into the program to set up their garden layout.

Identify **three** pieces of data that the user may input into this program.

1 Garden size

2 Elevation garden Items in garden

3 All Location of garden items

[3]

Examiner commentary

This candidate gives three reasonable inputs to the system so receives 3 marks.

Exemplar 2 2 marks

(iii) The user needs to input data into the program to set up their garden layout.

Identify **three** pieces of data that the user may input into this program.

1 Length and width of flower bed

2 Length and width of vegetable bed

3 Length of the path

[3]

Examiner commentary

2 marks given for length and width of the flower bed but the other answers are too similar to gain any more marks.

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Question 7 (b) (i)

Exemplar 1 4 marks

(b) The program is to be built using object oriented programming.

All items that can be added to the garden are declared as instances of the class `GardenItem`.

The class has the following attributes:

Attribute	Description	Example
`itemName`	The name of the item	Flowerbed
`length`	The length of the item in metres	2
`width`	The width of the item in metres	1

(i) The constructor method sets the attributes to values that are passed as parameters.

Write pseudocode or program code to declare the class `GardenItem` and its constructor. All attributes should be private and initialised through the constructor (e.g. `daisies = new GardenItem("Flowerbed",2,1)`). **[4]**

```
public class GardenItem
    private itemName
    private length
    private width
    public procedure new(newItemName, newLength, newWidth)
        itemName = newItemName
        length = newLength
        width = newWidth
    endprocedure
endclass
```

Examiner commentary

All four marks given here for an excellent answer written in clean pseudocode.

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Exemplar 2

2 marks

Write pseudocode or program code to declare the class `GardenItem` and its constructor. All attributes should be private and initialised through the constructor (e.g. `daisies = new GardenItem("Flowerbed",2,1)`). **[4]**

```
class GardenItem (new)
    private itemName
    private length
    private width
```

Examiner commentary

This response gets 2 marks: 1 for the class declaration and 1 for declaring the attributes. The candidate hasn't provided a constructor method so does not gain the associated marks.

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Question 7 (b) (iii)

Exemplar 1 4 marks

(iii) The Common Oak is a type of tree. It has a maximum height, length and width of 40 m. It can grow in sun and shade.

Write a statement, using pseudocode or program code, to declare an instance of tree for the Common Oak. Give the object the identifier `firstTree`.

firstTree = new Tree (40, true, true, "Common Oak", (40,40)

[4]

Examiner commentary

All four marks are given here. The marker considered the order that the parameters were shown in the previous question and allowed the marks as follow through.

Exemplar 2 1 mark

Write a statement, using pseudocode or program code, to declare an instance of tree for the Common Oak. Give the object the identifier `firstTree`.

~~Common Oak~~

firstTree = height < 40, lenght < 40, widh < 40

& Sun = true, shade = true [4]

Examiner commentary

Just one mark given for using the correct identifier. The rest of the response is incorrect.

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Question 7 (b) (iv)

Exemplar 1 — 4 marks

(iv) The classes `GardenItem` and `Tree` use get and set methods to access and alter their private attributes.

Write the get method `getItemName` and set method `setItemName` for class `GardenItem`. The set method takes the new value as a parameter.

Do not write any other methods, or re-declare the class.

```
function
public getItemName()
    return (this.ItemName)
endfunction

public procedure setItemName(newItemName)
    this.ItemName = newItemName
endprocedure.
```

[4]

Examiner commentary

This candidate has produced perfect code and gets all four marks.

Exemplar 2 — 0 marks

Do not write any other methods, or re-declare the class.

```
getItemName(name)
    Find in Tree class Tree name
    Item = Find in Tree name
    return Item
setItemName(name, OldName, NewName)
    Find in Tree oldName, replace oldName
    Replace OldName with newName
```

[4]

Examiner commentary

Many candidates seemed to struggle with this question and could not show any knowledge of constructor methods. This candidate receives no marks as the response is wholly incorrect.

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Question 7 (b) (v)

Exemplar 1

5 marks

(v) The trees in the garden layouts are stored in a 1-dimensional array, `treeArray`. The array can store a maximum of 1000 items. The array has global scope.

A procedure, `findTree`, takes as parameters:

- The maximum height of a tree
- The maximum width of a tree
- Whether the tree can live in full sun
- Whether the tree can live in full shade.

It searches the array, `treeArray`, for all trees that do not exceed the maximum height and width, and that can grow in the conditions available. If there are no suitable trees, a suitable message is output.

It outputs the name and details of the trees found in an appropriate message.

Call the get methods, `getItemName`, `getHeight`, `getWidth`, `getSun`, `getShade`, to access the attributes.

Write, using pseudocode or program code, the procedure `findTree`.

```
FindTree(maxHeight, maxWidth, sun, shade)
// findTree (// maxHeight, maxWidth, sun, shade)
For i in range 1 to 1000 len(treeArray[])
goal //
If maxHeight > getmaxHeight(treeArray[i]) and if
maxWidth > getWidth(treeArray[i]) and geoSun = sun = getsun(treearray[i])
and Shade = getShade(treearray[i])
Then print("A suitable tree is ", getItemName(treearray[i]) //,
"it has a height of ", getHeight(treearray[i]),
"a width of ", getwidth(treearray[i]),
"it can grow in full sun", getSun(treearray[i]),
"it can grow in full shade", getShad(treearray[i])
Else
print("There is no suitable trees that match your description")
End If
END LOOP
```

[6]

Examiner commentary

A good response but the candidate misses the final mark for outputting in the case when no trees are found as there would need to be a flag used and checked at the end of the iteration.

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Exemplar 2

2 marks

Write, using pseudocode or program code, the procedure `findTree`.

```
procedure findtree
    for x = 0 to len(treearray)
        if treearray(x).height > getheight
            if treearray(x).width > getwidth
                if treearray(x).gun = getgun
                    if treearray(x).shade = getshade
                        print treearray(x)
    else
        print("no trees found")
    next
end procedure
```

Examiner commentary

Two marks for this response: 1 for iterating to the end of the array and 1 mark for a correct output. The candidate doesn't correctly use the get methods, and incorrectly uses a greater than symbol (>).

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Question 7 (c)

Exemplar 1

8 marks

(c)* The programmer is designing the program to make use of caching and re-useable components.

Explain and evaluate the use of caching and re-useable components in the design of the garden program.

Caching is the process of storing frequently used data so it is retrieved, increasing the speed at which a program can run. In this program objects that are in use frequently being placed or their getters & setters called a lot, could be stored in the cache allowing the CPU to access them faster than if they were in RAM. Caching is one of the most important important features CPU speed.

Re-usable components are any section of code that can be used multiple times rather than being re-written each time. In this case an example is the Tree class, another example is that any libraries that the programmer is using. Re-usable components will decrease the size of the project as many sections only have to be written once, meaning if it's designed this way the development will be faster. The use of libraries also will speed up development as any code will already be tested. By designing re-usable components it makes designing & performing tests easier as each component can be tested separately from the program before it's implemented. Designing it with re-usable components is almost essential due to the modularity of playing garden objects and OOP, whereas caching is less essential but will greatly increase performance. Component design will mainly aid production in speed, ease and ability to debug and caching will benefit the final product in speed. [9]

Caching:
- storing frequently used data
- Speeds up computation
- Faster program
- Object placed multiple times can be held in cache

re-usable:
- Subroutines
- Objects like Coordinates
- Decrease size
- Library - already tested
- Easier to delegate
- Easier to debug

End:
- Re-use is essential to design - Better design
- Caching less important - Better performance
- Good.

Examiner commentary

An excellent response with a full range of knowledge, application and evaluative statements. Well worthy of the top mark band.

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Exemplar 2

3 marks

Explain and evaluate the use of caching and re-useable components in the design of the garden program.

Caching involves storing previous inputs or processes in memory to allow ~~quick~~ quicker interaction the next time as data is preloaded into small area of memory called cache. Caching can store ~~data~~ data about garden layout ~~so~~ in cache so when find trees compares trees, they can be compared to the data in cache, allowing comparisons to be done quicker meaning more can be done. This ~~means~~ means it doesn't have to fetch data from Ram ~~or memory~~ as its stored closer in the cache making it quicker. Reuseable components means that the program can be reused ~~make~~ multiple time and the elements of the program don't need to be reset.

Therefore in conclusion Caching is very useful because it improves efficiency and speed of processing. Creating a better program, as it quicker to use. [9]

Examiner commentary

The candidate provides some knowledge statements about caching and reusable components in a general sense. The discussion on caching is geared towards CPU caching which isn't appropriate to the question. As there is minimal application or evaluation this is a Level 1 response.

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